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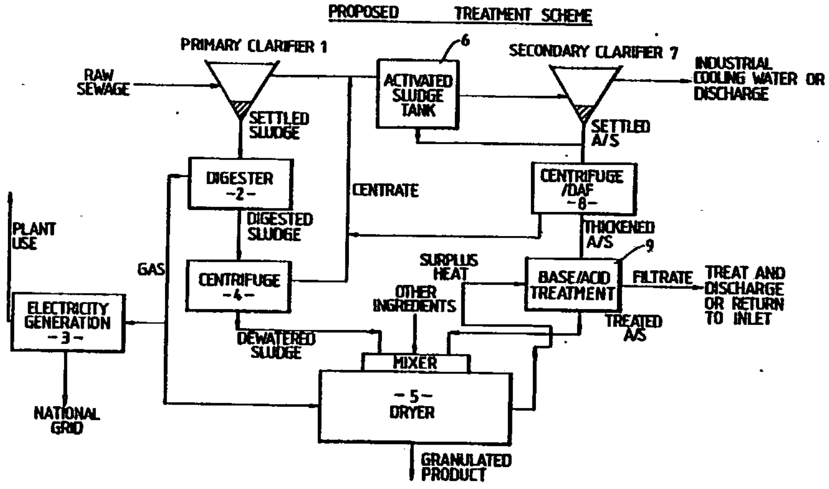

(57) Abstract

A process for treating effluent such as untreated biological effluent includes a primary clarifier (1) where sludge solids are settled out from a liquid sludge fraction. The sludge solids pass to a digester (2) where the sludge solids undergo anaerobic digestion to produce digested sludge and bio-gas. The digested sludge is dewatered and the liquid sludge fraction and the liquid component of the dewatered digested sludge is passed to an activated sludge tank (6). The resulting activated sludge solids are then concentrated by settlement, dewatered, and flocculated under alkaline and acidic conditions. The resultant acidic activated sludge solids are neutralized before and passed to a mixing and drying apparatus (5) where the solids are mixed with the digested sludge and dried using the bio-gas as a fuel.

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EFFLUENT TREATMENT PROCESS

This invention relates to the treatment of effluent waste matter of biological origin: for example sewage, effluent from the dairy industry or forms of previously treated biomass.

Such biomass effluents are conventionally treated by settlement followed by anaerobic digestion of the settled solids fraction to produce a stabilized sludge which is disposed of either by spraying on agricultural land or by dumping at sea. The liquid fraction is then often discharged without further treatment to coastal or estuary waters or, alternatively, receives further aerobic treatment before being discharged to rivers. Such processes result in the production of effluents contaminated both with pathogenic organisms and heavy metals which are undesirable from an environmental point of view. Moreover, legislation is becoming increasingly more restrictive on the dumping of waste material either on land or in the sea. Also, rises in fuel costs and hence transportation costs have led to large increases in disposal costs.

There have been various prior proposals for the treatment of liquid sludges. For example, in European Patent No. 0048723, there is disclosed a method of producing solid material for use as an animal feed, a fish feed or a fertilizer from activated or humus sludge which comprises treating a thickened liquid sludge having a solids content of at least 2% by weight with a base to raise the pH of the sludge to more than 8, acidifying the treated sludge to produce an activated flocculated sludge having a pH of 1 to 4, dewatering the acidified flocculated sludge and recovering the resulting solid material. However, such proposals do not result in a product from the original biomass effluent which would be sufficiently rich in nitrogen or low in metals content for some agricultural applications.

So far as industrial effluents are concerned, a high proportion of these, particularly those produced by the food and drinks industries, are characterized by containing large amounts of biodegradable organic matter. Typical examples of such effluents are those from breweries, farm effluents, slaughterhouses and meat packing wastes, meat and vegetable cannery effluents, palm oil mill wastes and confectionery and sweet manufacturing wastes. Chemical oxygen demand (COD) values in excess of 10,000 are commonly found in such effluents.

Generally, this type of effluent is suitable for treatment by biological systems such as anaerobic digestion and the activated sludge process. Both these processes generate liquid sludges having low solids contents as end products. This is a disadvantage in view of new legislation aimed at protecting the environment which will restrict or prohibit the dumping of liquid sludge on land or at sea or in rivers or lakes.

Moreover, the cost of disposal of liquid sludge has increased because of rises in transport costs. In view of the fact that both digested and activated sludge contain significant amounts of protein and other nutrients, there is the possibility of producing valuable end products if these are recovered in a dry form for use, for example, as fertilizer.

An object of the present invention is to provide an effluent treatment system which substantially eliminates liquid sludge disposal and which deals with primary settled solids.

Therefore, according to the present invention, there is provided a process for the treatment of biomass effluent comprising the steps of:

primary treatment of the effluent to produce a solid fraction;

dewatering the solid fraction;

treating the liquid fraction extracted by dewatering to produce a treated solids fraction;

flocculating and further dewatering the treated solids fraction; and, drying to produce solid by-products.

In one arrangement where there is a significant insoluble solids fraction, the primary treatment comprises initial settlement to settle out a solids fraction which is then treated in an anaerobic digester prior to dewatering. Alternatively, the settled solids fraction may be mechanically dewatered.

In a further alternative, where the solids fraction is mainly soluble, settlement may be omitted, and the effluent applied directly to an anaerobic digester.

Preferably the treating of the liquid fraction comprises a process selected from an activated sludge process or a humus sludge process.

The heat required for drying the product may be derived from the bio-gas produced in the anaerobic digestion stage or from incineration of the mechanically dewatered solids fraction.

If heavy metals, but no pathogens are present, the flocculating may be carried out under acidic conditions. The acid filtrate or concentrate from the process is then treated with lime or other alkali to precipitate heavy metals as hydroxides and the acidic dewatered treated solids fraction is neutralized before drying. Preferably heat is also applied to the acidic flocculated activated fraction to heat coagulate the fraction to facilitate dewatering by filtration or centrifugation.

In accordance with the various aspects of the invention, a distinction can be drawn between effluents containing pathogenic organisms and heavy metals such as are present in some effluents, meat works effluent and pig slurry, and effluents which contain no toxic material such as confectionery or brewery effluent.

Thus, in the case of effluents contaminated with pathogenic organisms or heavy metals, the invention may include flocculating and further dewatering the treated solids fraction first under alkaline and subsequently under acidic conditions and removing a substantial proportion of heavy metals present from the flocculated sludge.

Preferably the solid fraction resulting from alkali treatment is then treated with acid prior to dewatering. The separated digested solids are dried or treated with acid, neutralized and dried either separately or with the dewatered flocculated solids.

It has been found that the temperature at which the acid is added may have a marked effect on the concentration of solids obtained. There appears to be a rise in solid concentration with increasing temperature. Therefore, preferably, the addition of acid is carried out at temperatures in the range of from 20°C to 90°C, and advantageously at 80°C. Such temperatures may also improve filtration rates.

Moreover, the precise pH conditions also appear to be important with some treatments. In particular, a rise in alkaline pH may produce thickening of the biomass. It has been found that alkali should preferably be added in cold ie. ambient conditions.

In a preferred arrangement, alkali is added to cold biomass to a pH 10.7 ± .2 followed by acid addition at 80° to a pH of 1.8 ± .1.

The system is substantially energy self-sufficient and results in solid products free of pathogens and low in metals and environmentally acceptable and useful as organic fertilizers.

Non-toxic effluents may be treated by a variation of the sewage treatment process but which does not involve the use of alkali or mineral acid for sterilization and heavy metal removal.

Thus, the object of this aspect of the invention directed to non-toxic effluents is to provide an effluent treatment system for non-toxic effluents containing organic matter which substantially eliminates liquid sludge disposal and which provides useful by-products and which is substantially energy self-sufficient.

Therefore, according to this aspect of the invention, there is provided a process for treating non-toxic effluents containing soluble or insoluble bio-degradable organic matter comprising the steps of:

primary treatment of the effluent by anaerobic digestion to produce a digested sludge, dewatering the digested sludge to produce a solids fraction and a liquid fraction, treating the liquid fraction by a process selected from an activated sludge process or a humus sludge process or equivalent to produce a treated solids fraction, flocculating and further dewatering the treated solids fraction, and drying the dewatered treated solids fraction, together with, or separately from, the dewatered digested sludge solid fraction to produce solid by-products.

The primary treatment may be applied either to the whole effluent where the major part of the organic material is in a soluble form, or to a settled solids fraction where the bulk of the organic matter is insoluble in water.

The flocculating and further dewatering preferably comprises the addition of a suitable chemical such as polyelectrolyte followed by belt filtration or equivalent. The heat for drying the digested and treated solids may be obtained from the bio-gas produced in the anaerobic digestion stage.

The system of this aspect of the invention is substantially energy self-sufficient and results in end products essentially safe and environmentally acceptable as organic fertilizers or animal feed components. Heat may also be applied to the flocculated treated solids fraction to facilitate dewatering. The filtrate or centrate from the process may be returned to the plant inlet, the inlet to the activated sludge stage or discharged if the COD is of an appropriate value.

The invention will now be described by way of example with reference to the accompanying figures which are block diagrams of three embodiments of the general process arrangement and in which:

Figure 1 is a first embodiment of an effluent treatment process in accordance with the invention for treatment of biological waste;

Figure 2 is a second embodiment of an effluent treatment process in accordance with the invention for biomass treatment; and,

Figure 3 is a third embodiment of an effluent treatment process in accordance with the invention for the treatment of brewery effluent.

In the first arrangement raw sewage is introduced to a primary clarifier (1) where sludge solids are settled out from a liquid sludge fraction. The sludge solids pass from the primary clarifier (1) to a digester (2) where the sludge solids undergo anaerobic digestion. The products of digestion are digested sludge and bio-gas, mostly methane and carbon monoxide. The bio-gas produced is collected and used as a fuel for electricity power generation at generator (3) for use in the treatment process as will be explained and with excess electricity being available for the National Grid. The digested sludge passes to a centrifuge (4) for dewatering and then introduced to a mixer and dryer apparatus generally indicated (5), the digested sludge may be treated with hot alkali to kill bacteria and viruses, treatment with hot acid to remove metals and then neutralized prior to drying.

The liquid sludge fraction from the primary clarifier (1) and the liquid component or concentrate from the centrifuge (4) is passed to an activated sludge tank (6). At the activated sludge tank the liquid sludge fraction and other components are treated, in known manner, by the growth of micro-organisms under aerated conditions. The resulting activated sludge solids are then passed to a secondary clarifier (7) where the solids are again concentrated by settlement. The settled activated sludge solids are passed to a centrifuge (8) and the clarified liquid fraction discharged.

At the centrifuge (8) the activated sludge is thickened and removed liquid or concentrate is passed back to the activated sludge tank (6). The thickened activated sludge is then treated by means of the process described in European Patent No. 0048723 generally indicated by block (9). In that process the activated sludge is treated with a base so as to raise the pH to more than 8, then the treated sludge is made to spontaneously flocculate by subsequent addition of acid. The resultant treated sludge may be heat coagulated to facilitate further dewatering by filter press, belt filter or vacuum filter for example. As this aspect is a known process, reference is directed to the disclosure in European Patent No. 0048723 for full details. The acid filtrate is treated with lime, ammonia or other alkali to precipitate heavy metals as hydroxides, the treated filtrate being discharged or returned to the treatment plant inlet. Where the acid filtrate has a high COD value, this may be reduced by adding a compound capable of precipitating organic matter such as lignosulphonic acid and removing the precipitate prior to the addition of lime or by adding a soluble phosphate compound prior to the addition of lime. Alternatively, the neutralized filtrate may be passed through an anaerobic filter. The acidic activated sludge solids may be used to lower the pH value of the separated digested sludge or neutralized before passing to the mixing and drying apparatus (5) where the solids may be mixed with the digested sludge solids and dried. The material may also be mixed with other ingredients such as maize and vitamins or phosphate and potash compounds for example, then dried and granulated to produce a granulated commercial product useful as a feed or fertilizer.

Instead of a centrifuge (8) a dissolved air flotation (DAF) plant may be used to remove liquid from the activated sludge.

In the alternative arrangement in Figure 2, where the same numbering in a series commencing with 10 has been used for corresponding parts, settled primary sludge from the primary clarifier (11) is dewatered by a mechanical belt filter (20) with the liquid raw biomass fraction and the liquid from the dewatering passing to the activated sludge tank (16). The dewatered primary sewage solids are then incinerated at (21) to provide heat for drying and the ash is disposed of by landfill.

The remainder of the process works as described above in respect of the first arrangement, ie. flocculating and dewatering the thickened activated sludge under hot alkaline conditions to kill bacteria and hot acidic conditions to remove heavy metals followed by neutralization and drying.

Although it is preferred to incorporate an activated sludge process, the alternative is to produce a humus sludge by percolating the liquid fractions through a filter bed in which micro-organisms grow under aerobic conditions. Optionally, a reducing or oxidizing agent and/or chelating agent may be added to the acidified treated sludge to facilitate the removal of heavy metals and the inactivation of bacteria and viruses. Also, although it is preferred to incorporate the process disclosed in European Patent No. 0048723 the thickened activated sludge may, in the alternative, be simply dewatered under acidic conditions.

In Figure 3 where virtually all the COD load is in soluble form, a clarifier (1) is optional and may be omitted where there is no significant amount of insoluble solids. In the drawing, brewery effluent is introduced directly into an anaerobic digester (2) where it undergoes anaerobic digestion for a pre-determined length of time. The products of the digestion are a digested sludge and bio-gas, mostly methane and carbon monoxide. The bio-gas is collected and used partly for electricity generation (3) for use in the plant or sale to the National Grid and partly for drying the dewatered sludge as will be explained. The digested sludge contains a liquid fraction and a solids fraction and is passed from the digester (2) to a centrifuge (4) for dewatering. The dewatered solids fraction is passed to a mixing and drying apparatus generally indicated (5).

The liquid fraction from the centrifuge (4) is passed to an activated sludge tank (6) where the liquid fraction is treated in known manner by the growth of micro-organisms under aerated conditions and the resulting activated sludge solids are passed to a secondary clarifier (7) where the solids are again concentrated by settlement.

The settled activated sludge solids are then passed to a mixing tank (8) and mixed with a suitable polyelectrolyte or other chemical to induce flocculation of the activated sludge solids. The treated sludge is then thickened in a centrifuge or DAF plant (9). The concentrate is discharged or returned to the activated sludge tank (6). The thickened sludge from the centrifuge or DAF plant (9) may be passed directly to the mixing and drying plant (5), or optionally it may be further dewatered by heat treatment and belt filtration (10). In the mixing and drying plant (5) it may be mixed with digested sludge solids and/or other ingredients, and dried by means of the bio-gas energy source produced in the anaerobic digestion stage.

The drying plant (5) produces a granulated product suitable for use as an organic fertilizer or an animal feed component.

Preferably the process is operated as a continuous flow system using stirred tank reactors for example for the introduction of acid or alkali or other chemicals. Optionally, the stirred tank reactors are provided with heating elements or coils for temperature optimization.

There now follows a specific example of effluent treatment as applied to the treatment of sewage:

EXAMPLE

Untreated biological effluent in substantial quantity was subjected to primary settlement in a clarifier and the settled sludge with an average solids content of 4% was treated in an anaerobic digester with a retention time of 12 days. The bio-gas produced in the digester was used partly for the generation of electricity and partly as a source of heat.

Digested sludge was then centrifuged to give a dewatered sludge containing 30-35% dry solids.

The dewatered digested sludge was passed to a dryer operating at 110°C to yield a dry product having a mean nitrogen content of 3% and a phosphorus content of 3.5% (as P_2O_5). The cadmium content of the dry product was 3mg/kg well below the agricultural maximum limit of 20mg/kg. The dry product is useful as a general purpose fertilizer.

The liquid fraction from the dewatered digested sludge was treated by the activated sludge process. The activated sludge solids were then separated in a secondary clarifier and the clarified treated effluent was discharged to the sea.

The surplus settled activated sludge fraction with a dry solid content of approximately 0.5% was thickened in a dissolved air flotation plant (8) to yield a thickened sludge with a solids content of 4-5%. In accordance with European Patent No. 0048723 the pH of the thickened activated sludge was raised to 11.5 by addition of sodium hydroxide solution (40% w/v) with stirring and the alkaline sludge allowed to stand for 2 hours at ambient temperature. The pH of the sludge was then reduced to 2.2 by the addition of sulphuric acid (75% w/v) and the acidified flocculated sludge allowed to stand overnight before being dewatered in a filter press. The resulting filter cake (25%

dry solids) was removed from the filter press and neutralized with ammonia solution (0.88 S.G.) in a Z blade mixer and finally passed to the dryer where it was dried at a temperature of 110°C.

The dry product had a mean nitrogen content of 10.5%, a phosphorus content of 3.4% (as P_2O_5) and a cadmium content of 0.5mg/kg. Extensive field trials on a variety of crops showed that the product was very similar to dried blood in its effect on plant growth and crop yield.

CLAIMS

1. A process for the treatment of effluent such as untreated biological and industrial effluents comprising the steps of:

primary treatment of the effluent to produce a solid fraction;

dewatering the solid fraction;

treating the liquid fraction extracted by dewatering to produce a treated solids fraction;

flocculating and further dewatering the treated solids fraction; and,

drying to produce solid by-products.

2. A process according to claim 1, wherein the primary treatment comprises initial settlement to settle out a solids fraction which is then treated in an anaerobic digester prior to dewatering.

3. A process according to claim 1, wherein the primary treatment comprises initial settlement to settle out a solids fraction followed by mechanically dewatering.

4. A process according to claim 1, wherein the primary treatment comprises anaerobic digestion prior to dewatering.

5. A process according to any one of the preceding claims, wherein the treating of the liquid fraction comprises a process selected from an activated sludge process or a humus sludge

process.

6. A process according to claim 2 or 4, wherein heat required for drying the product is derived from bio-gas produced in the anaerobic digestion stage.

7. A process according to claim 3, wherein the mechanically dewatered solids fraction is incinerated to provide heat for the drying step.

8. A process according to any of the preceding claims, comprising flocculating the treated solids fraction under acidic conditions where heavy metals are present.

9. A process according to any of the preceding claims comprising flocculating and dewatering the treated solids fraction first under alkaline and subsequently under acidic conditions.

10. A process according to claim 9, wherein the acid treatment is carried out at a temperature in the range of 20°C to 90°C.

11. A process according to claim 9, wherein the alkali treatment is carried out at ambient temperature.

12. A process according to any one of claims 9 to 11, wherein alkali is added to biomass at ambient temperature to a pH of 10.7 ± .2 followed by acid addition at about 80°C to a pH of 1.8 ± .1.

13. A process according to claim 8,

comprising treating the filtrate or concentrate from the dewatered treated solids fraction with alkali to precipitate heavy metals as hydroxides and neutralizing the acidic dewatered treated solids fraction before drying.

14. A process for treating non-toxic effluents containing soluble or insoluble biodegradable organic matter comprising the steps of:

primary treatment of the effluent by anaerobic digestion to produce a digested sludge,. dewatering the digested sludge to produce a solids fraction and a liquid fraction, treating the liquid fraction by a process selected from an activated sludge process or a humus sludge process to produce a treated solids fraction, flocculating and further dewatering the treated solids fraction, and drying the dewatered treated solids fraction, together with, or separately from, the dewatered digested sludge solid fraction to produce solid by-products.

15. A process according to claim 14, wherein the primary treatment is applied to the whole effluent where the major part of the organic material is in a soluble form, or to a settled solids fraction where the major part of the organic matter is insoluble in water.

16. A process according to claim 14 or 15, wherein the steps of flocculating and further

dewatering comprises the addition of a polyelectrolyte followed by belt filtration.

17. A process for the treatment of sewage comprising the steps of:

primary settlement of the sewage solids to produce settled sludge and a liquid sludge fraction;

dewatering the settled sludge;

treating the liquid sludge fraction and the liquid sludge fraction extracted by dewatering by a process selected from an activated sludge process, a humus sludge process or equivalent to produce a treated solids fraction;

flocculating and further dewatering the treated solids fraction under alkaline and acidic conditions;

removing a substantial proportion of heavy metals present from the flocculated sludge; and,

drying to produce a material suitable for use as an organic fertilizer.

18. A process according to claim 17, wherein the settled sludge is treated in a digester prior to dewatering, the separated digested solids are dried or treated with acid, neutralized and dried either separately or with the dewatered flocculated solids.

19. A process according to claims 17 or 18, wherein the alkali is added to biomass at ambient

temperature to a pH of 10.7 ± .2 followed by acid addition at about 80°C to a pH of 1.8 ± .1.

20. Organic fertilizers produced by the process of any one of claims 1 to 19.

FIG.1

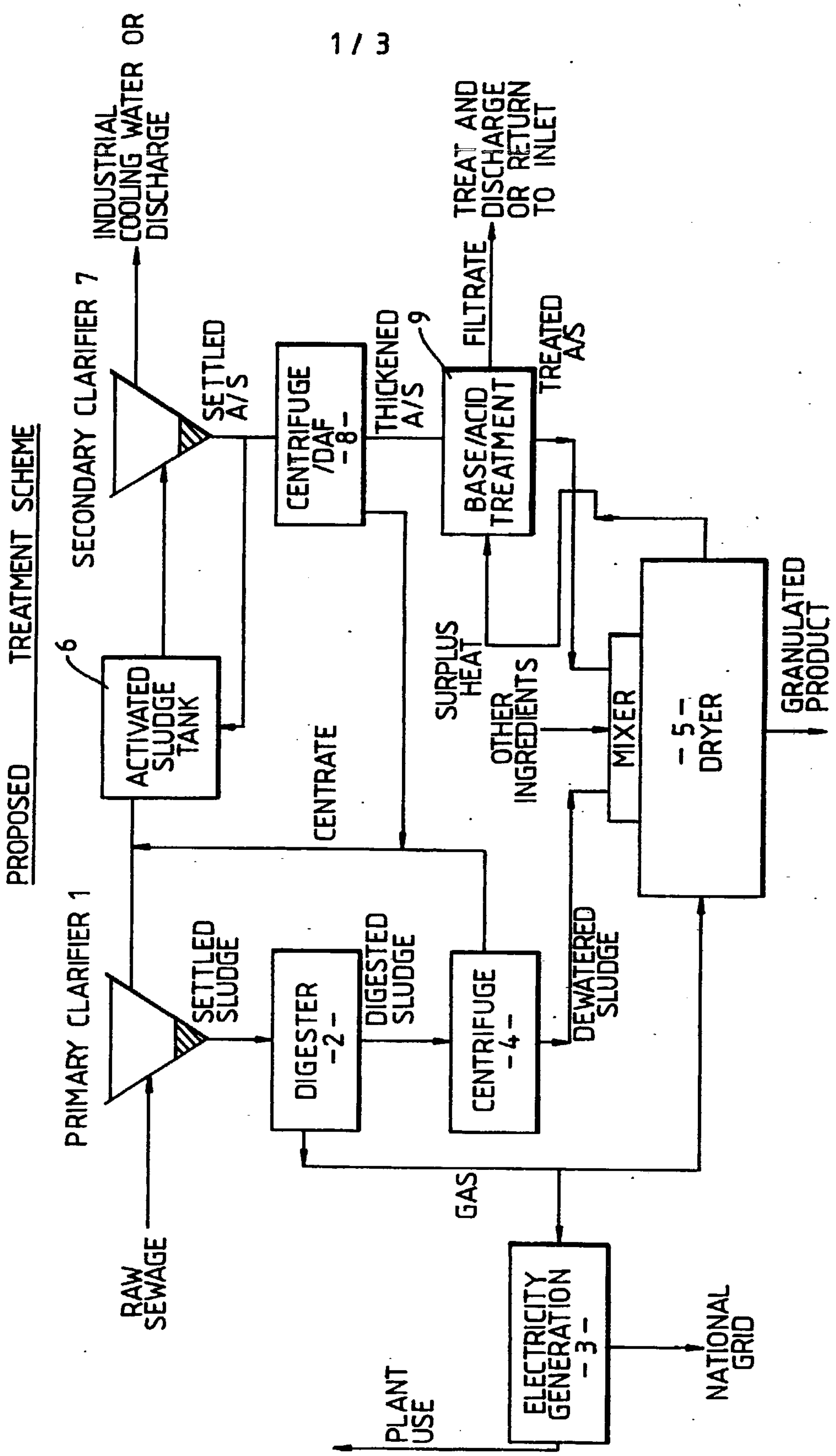

PROPOSED TREATMENT SCHEME
RAW SEWAGE
PRIMARY CLARIFIER 1
SETTLED SLUDGE
DIGESTER -2-
DIGESTED SLUDGE
CENTRIFUGE -4-
DEWATERED SLUDGE
GAS
ELECTRICITY GENERATION -3-
PLANT USE
NATIONAL GRID
ACTIVATED SLUDGE TANK
6
CENTRATE
SECONDARY CLARIFIER 7
INDUSTRIAL COOLING WATER OR DISCHARGE
SETTLED A/S
CENTRIFUGE /DAF -8-
THICKENED A/S
9
BASE/ACID TREATMENT
FILTRATE
TREAT AND DISCHARGE OR RETURN TO INLET
TREATED A/S
SURPLUS HEAT
OTHER INGREDIENTS
MIXER
-5- DRYER
GRANULATED PRODUCT

FIG. 2

ALTERNATIVE SCHEME

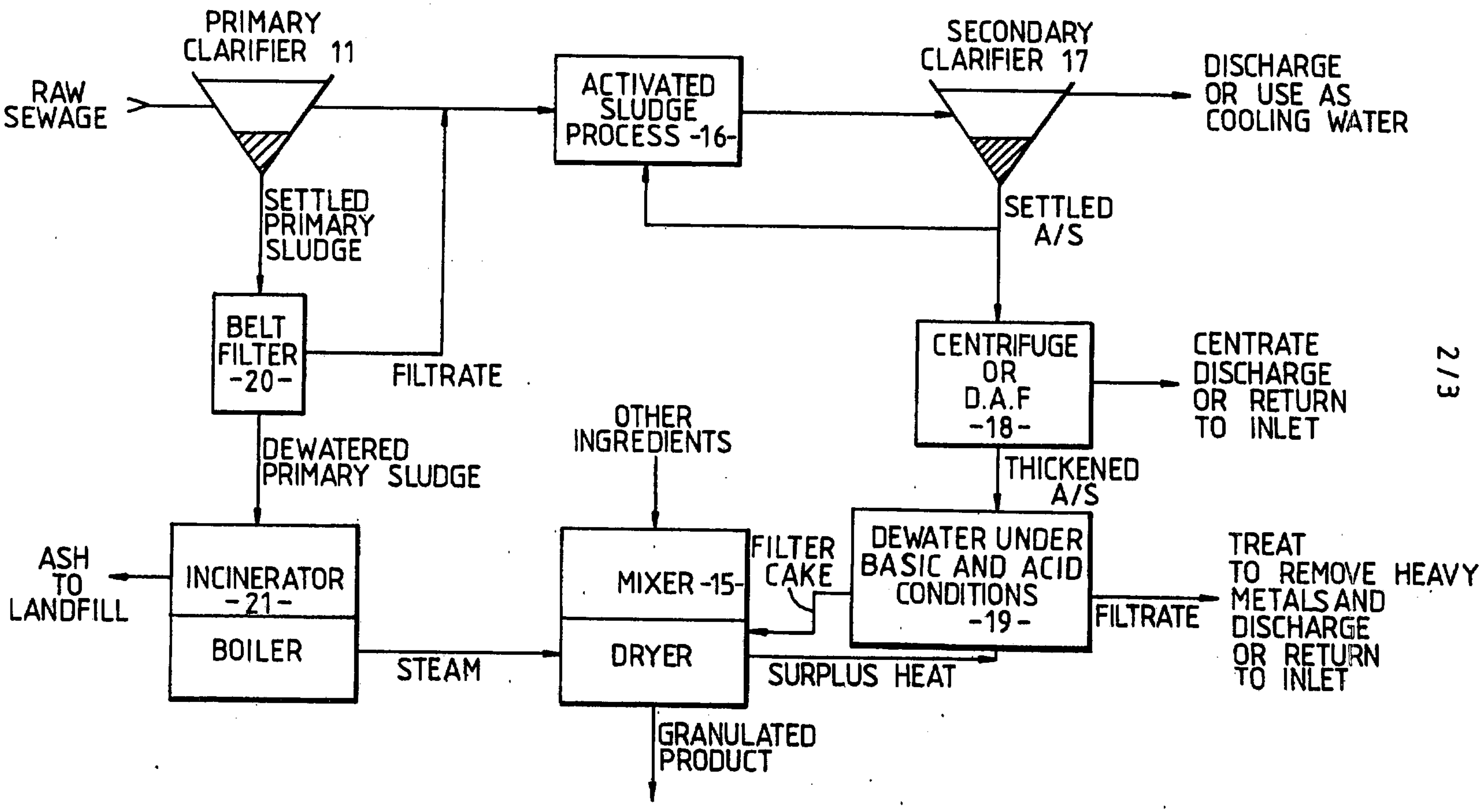
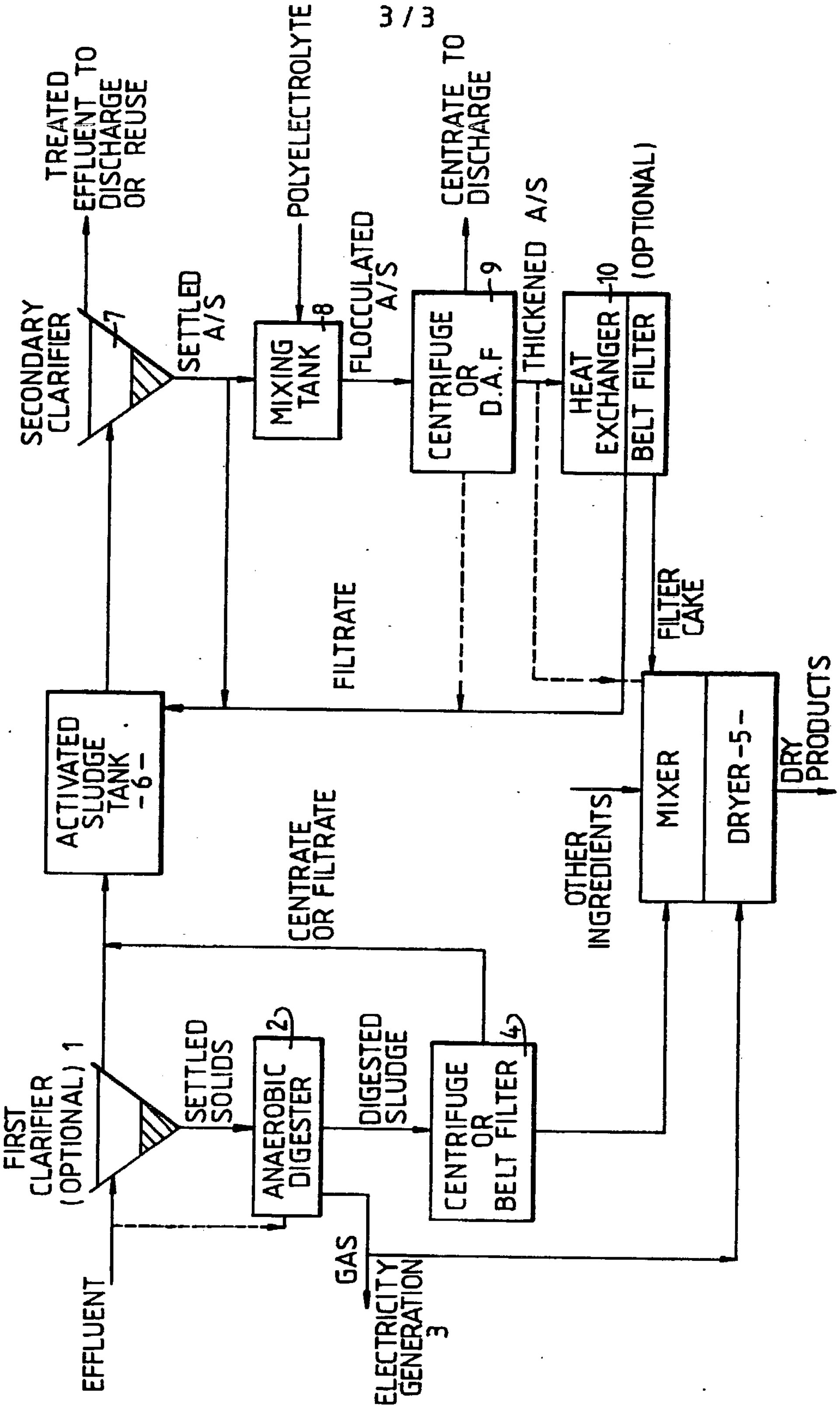


FIG. 3

TREATMENT OF NON-TOXIC EFFLUENT.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/00211

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 C02F11/12; C02F3/28; C05F7/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	C02F ; C05F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category°	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US,A,5 032 289 (A.P.MARTINEAU) 16 July 1991 see column 3, line 55 - column 4, line 11; figure 1 ---	1,3,20
X	DE,A,3 036 370 (LINDE AG) 19 May 1982 see claims 1,2; figure ---	1,2,7
A	WO,A,8 102 888 (OXFAM) 15 October 1981 cited in the application see the whole document -----	9-13,20

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

IV. CERTIFICATION

Date of the Actual Completion of the International Search 10 MAY 1993	Date of Mailing of this International Search Report 07. 06. 93
International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer GONZALEZ ARIAS,M.L.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9300211
SA 70347

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 10/05/93
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5032289	16-07-91	None	
DE-A-3036370	19-05-82	None	
WO-A-8102888	15-10-81	AU-A- 6920481	26-10-81
		EP-A,B 0048723	07-04-82

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82